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ABSTRACT

The Group Assessment of Logical Thinking (GALT) instrument has been widely used to gather cross-cultural data regarding the acquisition of logical thinking skills in adolescent children. This study of West German adolescents using the instrument adds further comparative data regarding the development of logical thinking skills. Additional data were gathered to determine correlations between logical thinking and the number of hours spent in the study of science and mathematics. Data analyses indicated the following: (1) logical thinking skills develop progressively over the ages of 12 to 15 years; (2) North American, Japanese, Philippine, and German data all show that boys score significantly higher than girls at each of the age levels tested; (3) the relationship between the number of hours of science instruction and logical thinking was highly significant; and (4) it was found that German students scored between Japanese and American students at the same ages. (YP)

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A COMPARATIVE STUDY of LOGICAL THINKING SKILLS: WEST GERMAN DATA

by

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SE 050 454

Paper presented at the Annual Conference of the National Association for Research in Science Teaching - San Francisco, March 30 - April 1, 1989

A COMPARATIVE STUDY OF LOGICAL THINKING SKILLS:

WEST GERMANY DATA

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ABSTRACT

The Group Assessment of Logical Thinking (GALT) instrument has been widely used to gather cross-cultural data regarding the acquisition of logical thinking skills in adolescent children. To date, American, Japanese and Philippine data have been compared and reported in the literature. These data can be analyzed to discover underlying educational and cultural similarities and differences. This study of West German adolescents using the same instrument adds further comparative data regarding the development of logical thinking skills. In addition, the variables of time spent learning science and mathematics were used to determine their relationship to scores on the GALT instrument.

Analyses and comparisons of the results indicated the following:

1) Logical thinking skills develop progressively over the ages 12 to 15 years. While research has shown that individual students often regress for a period of time, the overall pattern across each of the cultures tested show a steady acquisition of logical thinking skills.

2) North American, Japanese, Philippine and German data all show that boys score significantly higher than girls at each of the age levels tested. While these results may not be culture-free, they appear to be culture-independent. No testable explanation for this consistent cross-cultural phenomenon has yet been suggested.

3) The amount of mathematics or science taken each week in the

German sample ranged from two to seven hours. While there was not a significant relationship between the hours of mathematics and logical thinking, the relationship between the number of hours of science instruction and logical thinking was highly significant. This result, while not a confirmed cause and effect finding, is of great interest to science educators who have suggested that activity oriented science is best suited to the development to logical thinking skills.

4) Based on the reasonable assumption that grade level and chronological age can be equated without seriously affecting the data analysis, it was found that German students scored between Japanese and American students at the same ages, and that differences between each of the cultures tested were significant. The very weak performance on correlational reasoning of all students appears to be the result of an instrument anomaly, and not an indication that correlational reasoning is the last skill to develop among adolescent students.

While there are some differences across cultures in each of the specific sub-skills in logical thinking, there are more similarities in the patterns of how adolescents develop logical thinking skills than differences. That the proper teaching of science may help students acquire thinking skills has been postulated by many science educators. The results of this study in West Germany lend support to this hypothesis.

A COMPARATIVE STUDY OF LOGICAL THINKING SKILLS:

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INTRODUCTION

The initial development and validation of a group administered instrument for measuring the logical thinking skills of students has stimulated a number of comparative cross-cultural studies in science education. Prior to the development of the Group Assessment of Logical Thinking (GALT) instrument, individual Piagetian interview formats were commonly used to assess logical thinking. These interviews required extensive time commitments, use of hands-on equipment and a consistent interview protocol to insure reliable data. Without fluency in the language of the second culture, comparative cross-cultural research using interview protocols becomes extremely difficult. The GALT instrument has been translated into Japanese, German, Russian and Chinese, and educators from these countries believe the content to be relatively culture bias-free. This paper reports the results of testing in the West German context and compares these findings with previous research in the United States, Japan and to a lesser extent, the Phillipines.

The original GALT instrument, developed by Roadrangka, Yeany and Padilla (1983), contained twenty one items covering six specific thinking skill areas. These were: conservation, proportional reasoning, combinatorial logic, controlling variables, correlational logic and probabilistic logic. Further work by Mattheis, Coble and Spooner (1986), Bitner (1988) and Riley (1988) confirmed that a twelve item sub-test of the GALT containing two items from each specific

thinking skill is sufficient when gathering data over a large sample of students. The test is constructed such that the student must select both the correct answer and the correct reasoning on each item, or identify all of the possible combinations if that is required. The test includes simple, yet clear illustrations of any objects discussed in each item, reducing the chances of misreading or miscomprehending an individual item.

Mattheis, Coble and Spooner (1986) completed a large sample study comparing students in North Carolina and Japan. This study indicated that Japanese students scored significantly higher on most thinking skills and significantly higher overall. A rough comparison of the North Carolina data with results found by Atwater (1988) and Bitner (1987) indicates that North Carolina students are not widely different from those in Georgia and Arkansas, although exact age comparisons are not possible from the reported studies.

Although Bitner did not find significant gender differences, the large sample study by Mattheis, et al found significant differences in favour of males in both the North Carolina and Japan samples. Riley (1988) reported similar results of his testing results in the Philippines. All of these studies indicate a linear progression in the acquisiton of thinking skills over age. While Isaacs (1981) and Enyeart and Piburn (1981) reported that some students seem to regress in their thinking skills during early adolescence, this individual sporadic growth pattern is masked when testing over a large sample of students. A number of studies confirm that a sizable proportion of students do not ever develop formal thinking skills, and Wavering (1986) noted that even adolescents have areas of concrete operations which still need

developing before logical thinking skills can be acquired. He suggests that a strong activity oriented science program is the best way of alleviating these deficiencies.

PURPOSE

The primary purpose of this study was to collect and analyze data on logical thinking in West Germany. These data were compared with previous findings in other cultures and differences and similarities were noted. Additional data were gathered to determine correlations between logical thinking and the number of hours spent in the study of science and mathematics.

PROCEDURE

A random sample of 256 students aged 12 to 15 years was tested. These students came from six different schools in the West German state of Schleswig-Holstein, the most northern German region. Testing was done to sample urban, suburban and rural areas with a stratified sample of students from the three different types of schools which characterize the German education system. These schools types are the Gymnasium (academic stream), the Hauptschule (comprehensive) and the Realschule (pre-vocational). In harmony with earlier research designs, no testing was done in EMH and TMH classes. Testing was all completed during the month of May, 1987.

LIMITATIONS OF THE STUDY

In applying the GALT instrument across different cultures, one confronts the issue of instrument suitability. The instrument was developed and norms established in the state of Georgia, and while this did not appear to be a problem in the German context, the investigator's experience with research in the Peoples' Republic of China would suggest

caution be used in interpreting results. Just as the results from North Carolina, Georgia and Arkansas may not be representative of all of the United States, so the data from Schleswig-Holstein may not be representative of all of Germany. Visits to schools in West Germany showed a wide variety of educational patterns. For example, in Nordrhein-Westphalia, children begin taking physics, chemistry and biology as separate classes at age 10 or 11 while in both northern and southern Germany the curriculum organization is similar to common North American patterns.

DATA ANALYSES

Results of the data from West Germany support some of the previous cross-cultural similarities found in North American, Japan and the Philippines. The acquisition of logical thinking skills appears to be a generally linear progression with age over the adolescent years. While this result was not unexpected, it does indicate that regression found in previous individual testing does not manifest itself as a group effect that might cause educators to make special compensation for students over a particular age span.

In agreement with data from the United States, Japan and the Phillipines, German boys scored significantly higher than girls over all the early adolescent years. Previously unreported data from China agree with these findings. The question arises whether this phenomenon is culture-free, or at least culture-independent. Further work, particularly is examining the specific thinking skill differences, needs to be done to explain these results.

Overall cross-cultural results are shown on Figure 1. These results indicate that Japanese students score significantly higher

overall than those in West Germany, and that West German students score significantly higher than those in North Carolina. The percentage results in each specific thinking skill are also indicated in Figure 1, and it appears that the very low results in the area of correlational reasoning across all cultures may be more the result of the instrument than a firm indication that this thinking skill is the most difficult, and therefore the last skill to develop.

Of primary interest to educators are the results regarding the relationship between logical thinking and the amount of science and mathematics taken in the schools. While previous research indicates that logical thinking ability is a reasonable predictor of success in math and science, the German results are somewhat surprising. There was no relationship between the number of hours of math taken and logical thinking test scores, while there was a highly significant relationship between the number of hours of science taken and logical thinking. The single time testing nature of the research design does not permit a clear cause - effect distinction, but these findings do support the suggestion that science may be an important curriculum vehicle for the teaching of logical thinking skills.

IMPLICATIONS

The GALT instrument has demonstrated its usefulness in comparative education, and results from translated versions indicate it is relatively culture bias-free. Two problems with the instrument appear to remain: the format change on the combinatorial reasoning items, and the difficulty of the correlational reasoning items. The two answer format has proven successful in reducing guessing, and this format should be extended to the combinatorial items as well. Well selected

items should indicate the proper placement of combinatorial reasoning within other reasoning skills. Present combinatorial items are difficult to score fairly, and the format change makes internal contrasts more difficult to evaluate and analyze. Including combinatorial reasoning within the present format of correct answer-correct reason will not be a straightforward task as the instrument developers can surely testify. It should be possible, however.

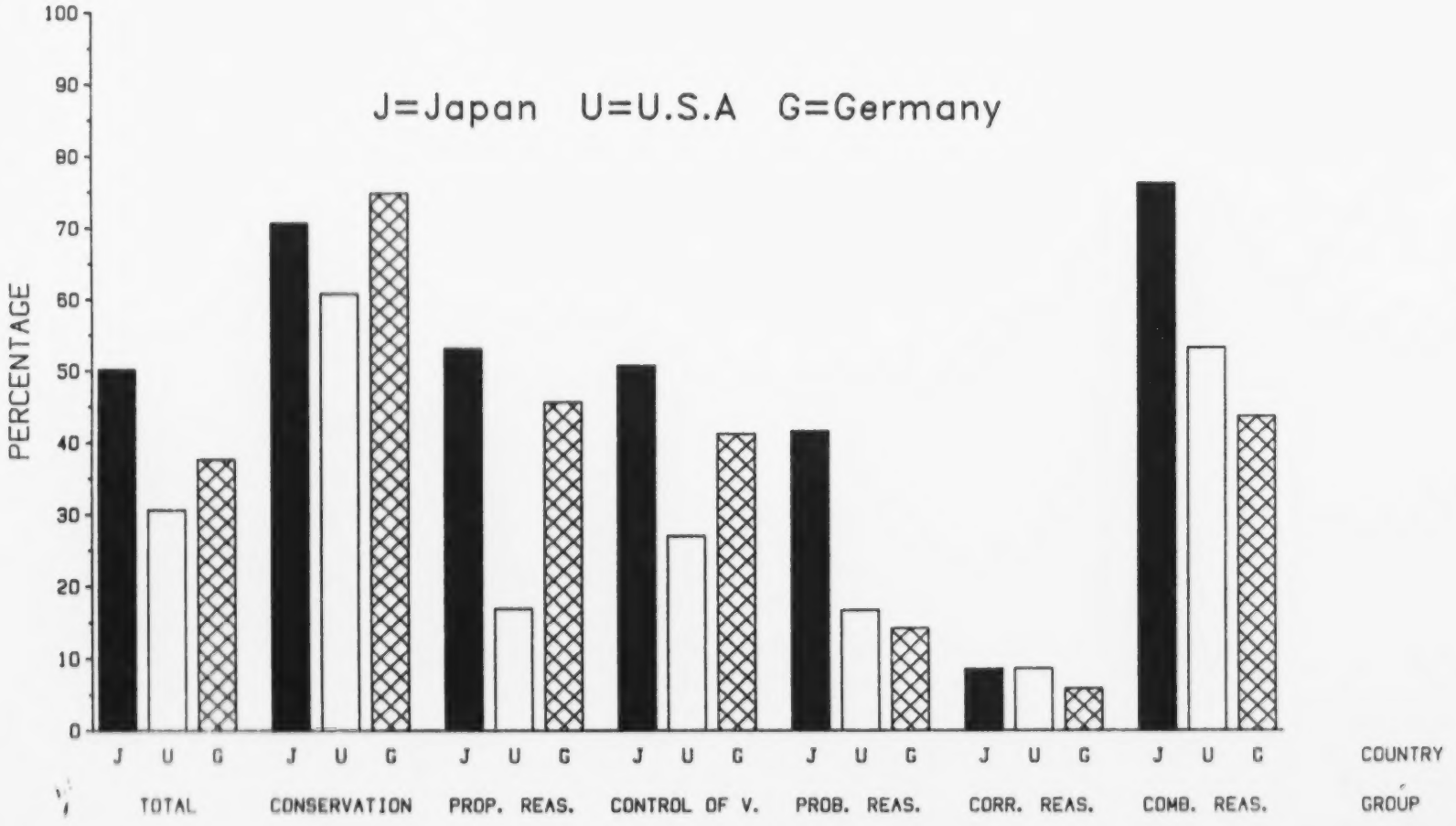
Correlational reasoning items fit well into the dual answer format, but the difficulty level seems inappropriate for the age group commonly tested - early adolescents. An analysis into the reasons these items cause difficulty should be sufficient to alter the items in a rational manner. The revised GALT instrument should then be published and available for general diagnostic and comparative research purposes.

For classroom teachers, the message is that science activities do appear to be reflected in students' improvement of thinking. While a strict cause and effect relationship has been yet demonstrated, the hypothesis that good thinking causes students to elect more science seems somewhat stretched. It is possible that activity based science courses do provide familiarity with the scientific materials (i.e., beakers, scales, balls) in a manner that gives a familiarity advantage to students taking the test. This hypothesis is worthy of investigation.

Comparative education researchers may find the rather consistent sex differences across various cultures of interest and deserving of further research and analysis. NAEP international studies have also confirmed sex differences in other countries, nearly always favoring

male students in science. It is of interest that sex differences previously found in mathematics achievement appear to have diminished in most western countries. Perhaps sex differences in science and logical reasoning will follow this trend.

Figure 1:
Comparisons by Total and by Specific Skills



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